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Observations of ground-state OH in the Large Magellanic Cloud

K. J. Brooks[1,2] and J. B. Whiteoak[2]
[1] *Astrophysics & Optics, The University of NSW, Sydney 2052, NSW, Australia; kbrooks@newt.phys.unsw.edu.au*
[2] *Australia Telescope National Facility, CSIRO, PO Box 76, Epping, NSW 2121, Australia*

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ABSTRACT

We have carried out a series of observations of the 1665- and 1667-MHz transitions of the $^2\Pi_{3/2}$, J=3/2 OH ground state towards six selected HII regions in the Large Magellanic Cloud (IRAS 05011-6815 and MRC 0510-689, 0513-694B, 0539-691, 0540-696B, 0540-697A) using the Australia Telescope Compact Array. The study has provided the first accurate positions for known 1665- and 1667-MHz OH masers as well as detecting several new masers. The regions all contain H_2O or CH_3OH masers but OH masers were detected in only four. The 1.6-GHz continuum emission was also imaged to investigate its spatial relationship to the associated OH maser. Although some masers are close to compact continuum components, in other cases they are near the continuum distribution boundaries and perhaps have been created as a result of the HII region interacting with the surrounding interstellar medium.

Key words: Magellanic Clouds - HII regions - masers - line:profiles - ISM:molecules

1 INTRODUCTION

The interstellar hydroxyl radical (OH) is ubiquitous in the molecular clouds of our Galaxy, and its spectral-line transitions have been widely studied over the last 30 yr. Observations of the 1.6-GHz ground-state $^2\Pi_{3/2}$, J=3/2 transitions have proven valuable in investigations of the physical and kinematic properties of the associated molecular clouds. OH maser emission found in or near many giant molecular clouds provides pointers for locations where star formation is occurring or possibly about to occur.

Attempts at similar studies of the Magellanic Clouds have been limited because little OH has been detected. In spite of several OH searches, previous detections, all in the Large Magellanic Cloud (LMC), consisted of maser emission near two HII regions and OH absorption against the continuum emission of two other HII regions (Whiteoak & Gardner 1976; Caswell & Haynes 1981; Haynes & Caswell 1981; Gardner & Whiteoak 1985; Caswell 1995). The OH deficiency may be related to the lower metallicity and stronger UV-radiation fields in the clouds compared with our Galaxy.

A limited number of other LMC masers have now been detected in 22-GHz transitions of H_2O (Whiteoak et al. 1983; Whiteoak & Gardner 1986) and 6-GHz transitions of CH_3OH (Sinclair et al. 1992; Ellingsen et al. 1994; Beasley et al. 1996). Except for Caswell's (1995) observations, the successful OH observations were obtained using the Parkes 64-m radio telescope with a beamwidth of 12.5 arcmin. The angular resolution plus uncertain positional results have hindered comparison of the OH results with those for the other masers. To further our knowledge of the OH detections, and to extend the search to the locations of the other molecular masers, we have carried out a series of observations of the 1665- and 1667-MHz transitions of the OH ground state, using the Australia Telescope Compact Array (ATCA), operated by the Australia Telescope National Facility, CSIRO. The observations also yielded the distribution of associated 1.6-GHz continuum emission.

2 OBSERVATIONS

The ATCA observations were carried out in several periods between 1994 March and 1996 November. Details of the instrument are given by Frater & Brooks (1992). The antenna spacings ranged from 153 m to 6 km. The observations and data processing were made using standard procedures. An observing cycle was adopted in which 40-min target observations were bracketed by 3-min observations of phase calibrator PKS 0823-500; in some cases two different targets shared the period between calibrator observations. This calibrator was also used to calibrate the spectral bandpass. Flux-density was calibrated by observing PKS 1934-638 (adopted as the ATCA primary calibrator), for which a flux density of 14.16 Jy was adopted. The correlator configuration consisted of 2048 channels extending over a 4-MHz band centered at 1665 MHz. This provided a channel spacing of 1.95 kHz (equivalent radial velocity of 0.35 km s^{-1}). Any

1665- and 1667-MHz transitions of OH in the LMC would be expected to appear in this band.

The correlated spectral outputs from pairs of ATCA antennas were processed mostly at the Paul Wild Observatory, Narrabri using a package based on the Astronomical Image Processing System (AIPS) produced by the US National Radio Astronomy Observatory. After amplitude, phase and bandpass calibration, the linearly polarized outputs were combined into total intensities. Contributions of continuum emission were removed from the spectral-line channels and stored in a separate database. The spectral-line database was split into databases for each OH transition, and the frequency scales converted into scales of heliocentric radial velocity. Data in the final databases were Fourier transformed, providing continuum and spectral-line images which were 'cleaned' to remove side-lobe fringes caused by using only a limited number of baselines. In this process, 'uniform' weighting was used for the imaging because it yielded the highest angular resolution. However, in some cases 'natural' weighting was used to image the continuum emission because this is more effective in defining the faint extended emission.

The selected targets included HII regions in which OH had been previously detected by Whiteoak & Gardner (1976), Caswell & Haynes (1981), Haynes & Caswell (1981), and Gardner & Whiteoak (1985): MRC 0510-689 (MC23, N105A), MRC 0539-691 (MC74, N157A), MRC 0540-696B (MC76, N160A), and MRC 0540-697A (MC77, N159). It also included MRC 0513-694B (MC24, N113C), an HII region associated with the brightest H_2O maser found in the LMC (Whiteoak & Gardner 1986), and IRAS 05011-6815, a suspected ultra-compact HII region associated with a bright CH_3OH maser (Beasley et al. 1996).

3 RESULTS

OH maser emission or thermal absorption has been detected near all regions, except MRC 0539-691, associated with the Doradus nebula. In this case, the absorption detected with the Parkes radio telescope is presumably extended, with a surface density too low to be detected with the ATCA. Table 1 summarizes the OH results for the detected cases. The positional errors are given in parentheses. A discussion of the individual results follows.

3.1 IRAS 05011-6815

A CH_3OH maser was detected towards this region by Beasley et al. (1996). It showed three components located at RA(J2000) = $05^h01^m01^s.85$, Dec(J2000) = $-68°10'28''.3$, with heliocentric velocities in the range 265.6 - 267.9 km s^{-1}. The object had been selected from the IRAS Point Source Catalogue (1985) on the basis of the criteria suggested by Wood & Churchwell (1989) for ultra-compact HII (UCHII) regions.

Both 1665- and 1667-MHz OH maser emission was detected in images created from the spectral database using a beam of extent 7.0 x 3.4 arcsec^2 (full width to half maximum). Fig. 1a,b shows the OH spectra of this emission. The 1665-MHz spectrum consists of a narrow feature at a heliocentric radial velocity of 267.6 km s^{-1} peaking at a flux density of 230 mJy beam^{-1}. Its measured position is RA(J2000) = $05^h01^m01^s.91$ ($\pm0^s.03$), Dec(J2000) = -$68°10'28''.5$ ($\pm0''.2$). The 1667-MHz spectrum contains a narrow feature at 266.2 km s^{-1} with a peak flux density of 129 mJy beam^{-1}, and possibly a fainter narrow feature at 268.7 km s^{-1}. The position is similar to that of the 1665-MHz emission. The similarity of OH and CH_3OH positions and velocities suggests a common origin for the molecules.

The IRAS position differs from the OH maser position by $1^s.06$ in right ascension and $-17''.8$ in declination. A 1.6-GHz continuum image made with a beam size of 12.3 x 5.8 arcsec^2 showed no evidence of any continuum emission towards or near the maser, to an upper limit of 0.5 mJy beam^{-1}. This is consistent with the results of Beasley et al. (1966), who failed to detect any continuum emission at 8.8 GHz.

3.2 MRC 0510-689 (MC23, N105A)

H_2O and CH_3OH masers have already been detected in this HII region, which has an H109α hydrogen recombination-line velocity of 253 km s^{-1} (McGee, Newton & Brooks 1974). The H_2O maser was discovered by Scalise & Braz (1981), and further observed by Whiteoak et al. (1983) and Whiteoak & Gardner (1986). Unpublished observations by J. B. Whiteoak, T. Kuiper, P. Harbison and R-S Peng using the 70-m antenna of NASA's Canberra Deep Space Communication Complex (CDSCC) yield a preliminary position for the H_2O maser of RA(J2000) = $05^h09^m52^s.2$, Dec(J2000) = $-68°53'32''$, and a velocity range of 253-268 km s^{-1}. The CDSCC positions should be accurate to better than ±3 arcsec. The CH_3OH maser was discovered with the Parkes 64-m radio telescope by Sinclair et al. (1992), and was subsequently re-observed at Parkes and imaged with the ATCA by Ellingsen et al. (1994). The emission, extending over the velocity range 249-253 km s^{-1}, had a peak flux density of 170 mJy. However, there was some uncertainty in its measured position and we have reobserved the maser in 1997 March with the ATCA. The results yielded a well-defined position RA(J2000) = $05^h09^m58^s.66$ ($\pm0^s.01$), Dec(J2000) = $-68°54'34''.1$ ($\pm0''.1$). 1665-GHz OH maser emission in the HII region was discovered at Parkes by Haynes & Caswell (1981), who determined a position with an rms uncertainty of 22 arcsec; it was later re- observed by Gardner & Whiteoak (1985).

Our ATCA maser images were produced with a beamwidth of 4.1 x 7.7 arcsec^2. Both 1665- and 1667-GHz emission was detected; Figs 2a,b show the spectra derived near the maser centre. The 1665-MHz spectrum essentially consists of a narrow feature with a peak flux density of 580 mJy beam^{-1}, centred at 253.4 km s^{-1}. A weak feature of flux density about 90 mJy beam^{-1} may also be present at 255.8 km s^{-1}. The 1667-MHz spectrum contains a peak flux density of 248 Jy beam^{-1}, at a velocity of 254.2 km s^{-1}. The 1665-MHz narrow feature at 253.4 km s^{-1} is centred at RA(J2000) = $05^h09^m51^s.94$ ($\pm0^s.02$) , Dec(J2000) $-68°53'28''.5$ ($\pm0''.3$). Within the errors, this is similar to the 1667-MHz maser emission position.

The distribution of continuum emission (Fig. 3) was imaged with a restoring beam of size 10 x 6 arcsec^2 elongated at position angle 101°. The maximum flux density of 19 mJy beam^{-1} occurs in a compact region centred at RA(J2000) =

$05^h09^m52^s.86$ ($\pm0^s.05$), Dec(J2000) = -68°53′01″.0 ($\pm0''.1$). The OH maser emission is not associated with any continuum maxima, but is on the southern edge of the continuum distribution, perhaps where the HII region is interacting with the interstellar medium. The H_2O maser has a similar location but the CH_3OH maser is offset by more than 1 arcmin and is significantly south of the continuum distribution.

3.3 MRC 0513-694B (MC24, N113)

This HII region was selected because it contains by far the brightest H_2O maser in the LMC; in 1984 the line profile contained two narrow features with peak flux densities of about 22 Jy and velocities of 247.3 and 254.5 km s^{-1} (Whiteoak & Gardner 1986). The detected maser emission covers the velocity range 238-258 km s^{-1}. The preliminary CDSCC position is RA(J2000) = $05^h13^m25^s.3$, Dec(J2000) = -69°22′44″.

Maser images formed with a beamsize of 6.9 x 5.5 arcsec^2 yielded well-defined 1665-MHz maser emission. Its spectrum (Fig. 4) shows a narrow feature at a velocity of 248.3 km s^{-1} with a peak flux density of 257 mJy beam^{-1}. The emission is centred at RA(J2000) = $05^h13^m25^s.18$ ($\pm0^s.05$), Dec(J2000) = -69°22′46″.0 ($\pm0''.1$)

Fig. 5 shows the distribution of 1.6-GHz continuum emission imaged with a 9.6 x 6.3 arcsec^2 beam elongated at a position angle of 6.9°. Superimposed on faint extended emission are three regions centred at positions RA(J2000) = $05^h13^m17^s.74$ ($\pm0^s.03$), Dec(J2000) = -69°22′24″.0 ($\pm0''.1$), RA(J2000) = $05^h13^m21^s.65$ ($\pm0^s.04$), Dec(J2000) = -69°22′39″.9 ($\pm0''.1$), RA(J2000) = $05^h13^m25^s.09$ ($\pm0^s.09$), Dec(J2000) = -69°22′45″.4 ($\pm0''.2$) The respective peak flux densities are 51, 31 and 10 mJy beam^{-1}. The regions are quite compact; their sizes, corrected for the imaging beam shape, are in the range 3-7 arcsec. An image obtained using natural weighting shows that the faint emission extends in right ascension from $05^h13^m00^s$ to $05^h13^m50^s$, and in declination from -69°24′ to -69°16′.

In summary, the OH and H_2O masers probably originate in a common cloud region associated with the most eastern small-diameter continuum component.

3.4 MRC 0540-696B (MC76, N160A)

An H_2O maser was detected in this HII region (Whiteoak et al. 1983; Whiteoak & Gardner 1986) which has an H109α recombination-line velocity of 254 km s^{-1} (McGee et al. 1974). The preliminary CDSCC position of the maser is RA(J2000) = $05^h39^m43^s.7$, Dec(J2000) = -69°38′31″. Caswell & Haynes (1981) discovered a 1665-MHz OH maser which they believed could be associated with the H_2O maser that Scalise & Braz (1981) had reported in N159. However, later OH observations by Gardner & Whiteoak (1985) supported a location of the OH maser in MRC 0539-696B. Imaging the ATCA spectral data with a restoring beam of width 7.6 x 2.8 arcsec^2 confirmed the association of the maser with this HII region.

Fig. 6 shows the spectrum of the maser emission. A narrow feature with a peak flux density of 221 mJy beam^{-1} is present at a velocity of 248.6 km s^{-1}. A fainter feature of amplitude about 80 mJy beam^{-1} is centred at about 244.5 km s^{-1}. The position determined for the stronger feature is RA(J2000) = $05^h39^m39^s.0$ ($\pm0^s.5$), Dec(J2000) = -69°39′11″.1 ($\pm0''.1$) Within the errors of measurement, the weaker feature is located at the same position. There was no detection of 1667-MHz emission using the same beam size to an upper limit of 25 mJy.

Caswell (1995) recently detected maser emission in ATCA observations of the 6035-MHz, excited-state, OH transition centred at a position offset from the 1665-GHz OH position by -$0^s.08$ in right ascension and $0''.1$ in declination. The position coincidence suggests a common origin for the two masers.

Fig. 7 shows the distribution of the 1.6-GHz continuum emission, imaged with a circular restoring beam of 6-arcmin diameter. Superimposed on a faint extended emission is a small-diameter component centred at RA(J2000) = $05^h39^m46^s.15$ ($\pm0^s.5$), Dec(J2000) = -69°38′39″.4 ($\pm0''$), with peak flux density of 105 mJy beam^{-1}. The OH maser is not associated with this feature, but with a fainter continuum component about 50 arcsec to the south-west. The H_2O maser position is about 15 arcsec north-west of the main continuum component and, despite the significant possible errors in the position estimates, cannot be associated with the OH maser.

3.5 MRC 0540-697A (MC77, N159)

This HII region is one of the brightest in the LMC, and yielded the first detection of interstellar OH (in absorption) in this galaxy (Whiteoak & Gardner 1976). ATCA observations of 5-GHz spectral-line and continuum distributions (Hunt & Whiteoak 1994) revealed a second compact radio component that is totally obscured at optical wavelengths by a dense interstellar cloud. Subsequent mm-wavelength observations (e.g. Chin et al. 1997) have established this cloud as one of the best target candidates for molecular-line studies of the LMC. Scalise & Braz (1981) claimed to detect an H_2O maser in this HII region, but subsequent attempts to confirm the detection were unsuccessful (see e.g. Whiteoak & Gardner 1986). Finally, a maser was detected beyond the south-western boundary of the HII region (unpublished observations made with the Parkes 64-m radio telescope). The preliminary CDSCC position is RA(J2000) = $05^h39^m31^s.2$, Dec(J2000) = -69°47′28″.

Fig. 8 shows the distribution of 1.6-GHz continuum emission obtained with the ATCA and imaged with a circular restoring beam of 6-arcmin diameter. The maximum flux density of 91 mJy beam^{-1} is associated with the optically obscured compact continuum component, centred at RA(J2000) = $05^h39^m37^s.60$ ($\pm0^s.02$), Dec(J2000) = -69°45′25″.9 ($\pm0''.1$).

Imaging of the OH data revealed no maser emission, but a 1667-MHz absorption feature (Fig. 9) was found to be centred at RA(J2000) = $05^h39^m37^s.60$ ($\pm0^s.02$), Dec(J2000) = -69°45′25″.9 ($\pm0''.1$), i.e. coincident with the compact continuum component. The feature has a central velocity of 254.9 km s^{-1} and a maximum line-to-continuum ratio of -0.30. Efforts to detect OH absorption towards the fainter compact region further to the east yielded an upper limit of -0.15 in line-to-continuum ratio. Clearly the results support the existence of a dense molecular cloud over the western

side of the HII region. This is the only ATCA detection of OH absorption in the HII regions observed in this survey.

4 CONCLUSIONS

This study has provided the first accurate positions for 1665- and 1667-MHz OH masers in the LMC, and reveals the relationship between the masers and associated HII regions. In three of the four cases (out of the six selected HII regions) in which OH masers were found, their positions were very close to those of other masers; in the fourth, the positions differed considerably. Although some masers were close to compact continuum components, others were near the continuum distribution boundaries and may have been created as a result of the HII region interacting with the interstellar medium.

The flux densities of the 1665-MHz masers ranged between 221 and 580 mJy; for an assumed LMC distance of 55 kpc, the equivalent range in 'luminosity' is 669 to 1754 Jy kpc^2. Our detection limit was equivalent to a luminosity of 150 Jy kpc^2. In the OH maser statistics of our Galaxy (Caswell & Haynes 1987), 50 per cent of the masers with intensities above this threshold have intensities equal to or greater than the detected LMC masers. It should be possible to detect additional masers in future surveys of the LMC. An unbiased survey of HII regions would be required to provide firm statistical trends for comparison with a survey made in our Galaxy.

5 ACKNOWLEDGMENTS

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REFERENCES

Beasley A. J., Ellingsen S. P., Claussen M. J., Wilcots E., 1996, ApJ, 459, 600
Caswell J. L., 1995, MNRAS, 272, L31
Caswell J. L., Haynes R. F., 1981, MNRAS, 194, 33P
Caswell J. L., Haynes R. F., 1987, Aust. J. Phys, 40, 215
Chin Y.-N., Henkel C., Whiteoak J. B., Millar T. J., Hunt M. R., Lemme C., 1997, A&A, 317, 548
Ellingsen S.P., Whiteoak J. B., Norris R. P., Caswell J. L., Vaile R. A., 1994, MNRAS, 269, 1019
Frater R. H., Brooks J. W., (Eds), 1992, J. Electr. Electron. Eng. Aust., 12, no.2 (Special Issue)
Gardner F. F.,Whiteoak J. B., 1985, MNRAS, 215, 103
Haynes R. F., Caswell J. L., 1981, MNRAS, 197, 23P
Hunt M. R., Whiteoak J. B., 1994, Proc. Astr. Soc. Aust., 11, 68
IRAS Point-Source Catalog 1985, IRAS Science Working Group (Washington: US Government Printing Office)
McGee R. X., Newton L., Brooks J. W., 1974, Aust. J. Phys., 27, 729
Scalise E., Braz M. A., 1981, Nature, 290, 36
Sinclair M. W., Carrad G. J., Caswell J. L., Norris R. P., Whiteoak J. B., 1992, MNRAS, 256, 33P
Whiteoak J. B., Gardner F. F., 1976, MNRAS, 176, 25P
Whiteoak J. B., Gardner F. F., 1986, MNRAS, 222, 513
Whiteoak J. B., Wellington K. J., Jauncey D. L., Gardner F. F., Forster J. R., Caswell J. L., Batchelor R. A., 1983, MNRAS, 205, 275
Wood D. O. S., Churchwell E., 1989, ApJ, 340, 265

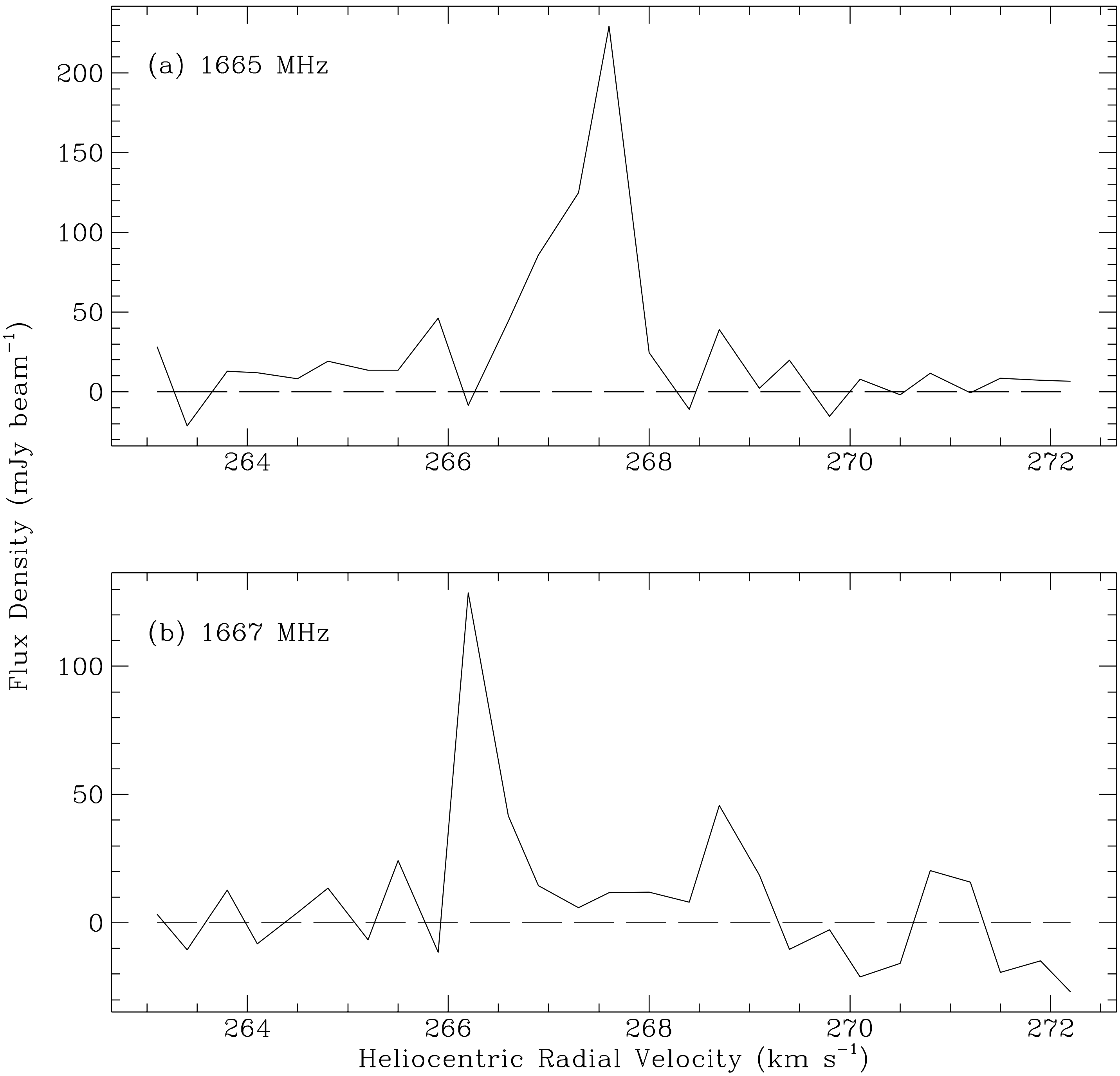
6 CAPTIONS TO FIGURES:

Fig. 1: Spectra of (a) 1665-MHz and (b) 1667-MHz OH maser emission near IRAS 05011- 6815.
Fig. 2: Spectra of (a) 1665-MHz and (b) 1667-MHz OH maser emission in MRC 0510-689.
Fig. 3: Distribution of 1.6-GHz continuum emission of MRC 0510-689. Contour levels are 0.02, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5, 0.6, 0.7 units of 27.8 mJy beam^{-1}. The cross and triangle mark OH and H_2O maser positions, respectively. The position of the nearest CH_3OH maser is 45 arcsec south of the southern limit in the figure.
Fig. 4: Spectrum of 1665-MHz OH maser emission in MRC 0513-694B.
Fig. 5: Distribution of 1.6-GHz continuum emission of MRC 0513-694B. Contour levels are 0.05, 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0 units of the peak flux density of 51.5 mJy beam^{-1}. The cross and triangle mark OH and H_2O maser positions, respectively.
Fig. 6: Spectrum of 1665-MHz OH maser emission in MRC 0540-696B.
Fig. 7: Distribution of 1.6-GHz continuum emission of MRC 0540-696B. Contour levels are 0.02, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0 units of the peak flux density of 105 mJy beam^{-1}. The cross, triangle and star mark OH, H_2O and 6035-MHz excited state OH maser positions, respectively.
Fig. 8: Distribution of 1.6-GHz continuum emission of MRC 0540-697A. Contour levels are 2, 5, 10, 20, 30, 40, 50, 60, 70, 80 and 90 mJy beam^{-1}.
Fig. 9: Spectrum of 1667-MHz OH absorption against the brightest compact component of MRC 0540-697A.

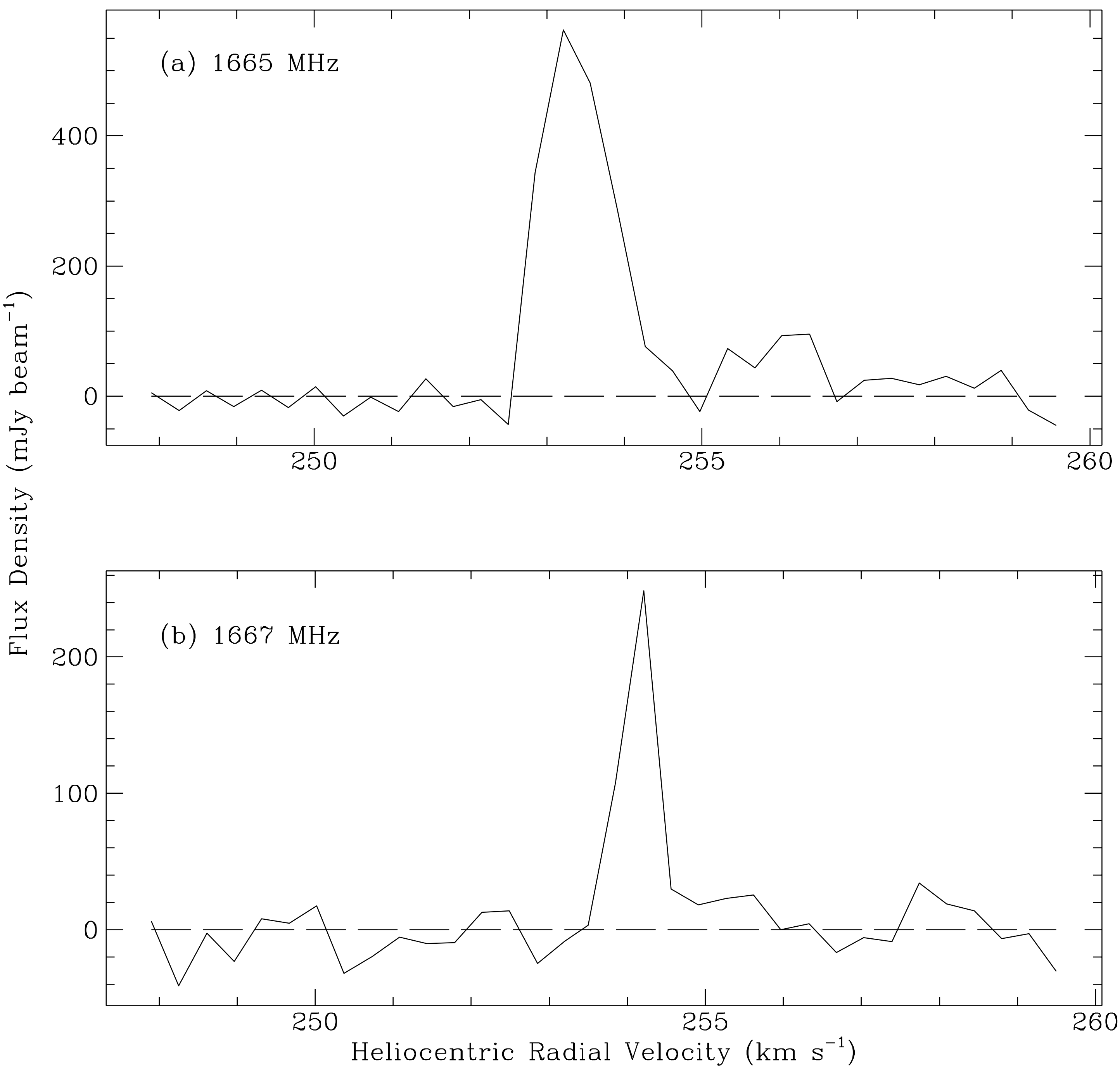
Table 1. Summary of OH Spectra Parameters

Region	Recomb Velocity km s^{-1}	OH line MHz	RA(2000) h m s	DEC(2000) ° ′ ″	Peak Velocity km s^{-1}	Peak Intensity mJy $beam^{-1}$
IRAS 05011		1665	05 01 01.91 (0.03)	-68 10 28.5 (0.2)	267.6	230
		1667	05 01 01.91 (0.08)	-68 10 28.1 (0.4)	266.2	129
MRC 0510-689	253	1665	05 09 51.94 (0.02)	-68 53 28.5 (0.2)	253.4	580
(MC23, N105a)		1665	05 09 52.18 (0.12)	-68 53 28.7 (0.2)	255.8	90
		1667	05 09 52.00 (0.03)	-68 52 28.6 (0.1)	254.2	248
MRC 0513-694B		1665	05 13 25.18 (0.05)	-69 22 46.0 (0.1)	248.3	257
(MC24, N113)						
MRC 0540-696B	254	1665	05 39 39.00 (0.5)	-69 39 11.1 (0.1)	248.6	221
(MC76, N160A)		1665	05 39 39.15 (1)	-69 39 10.9 (2)	244.5	80
MRC 0540-697A	254	1667	05 39 37.60 (0.02)	-69 45 25.9 (0.1)	254.9	-0.3 [a]
(MC77, N159)						

[a] line / continuum



(a) 1665 MHz
(b) 1667 MHz
Flux Density (mJy beam^{-1})
Heliocentric Radial Velocity (km s^{-1})
200
150
100
50
0
264
266
268
270
272



(a) 1665 MHz
(b) 1667 MHz
Flux Density (mJy beam^{-1})
Heliocentric Radial Velocity (km s^{-1})
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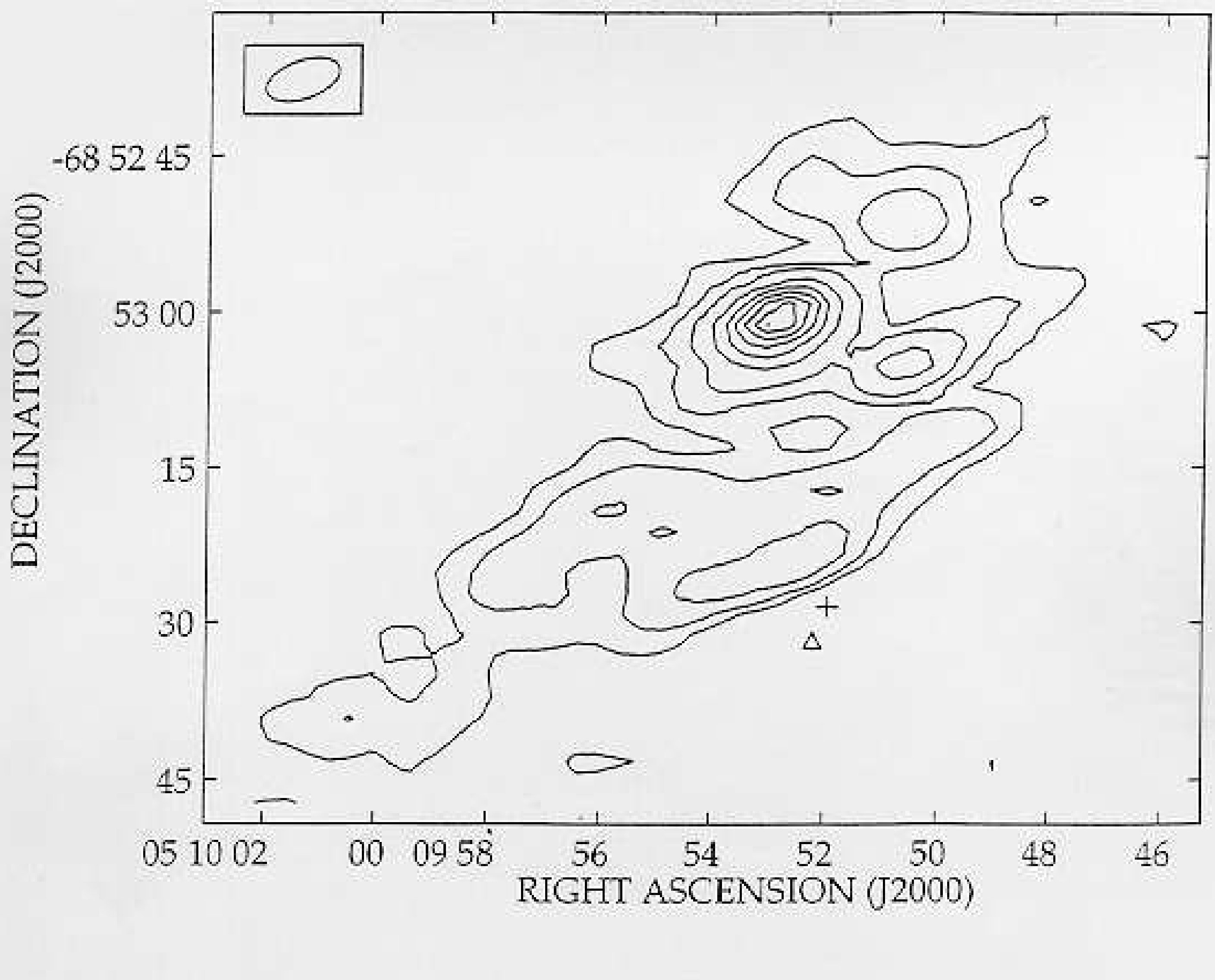
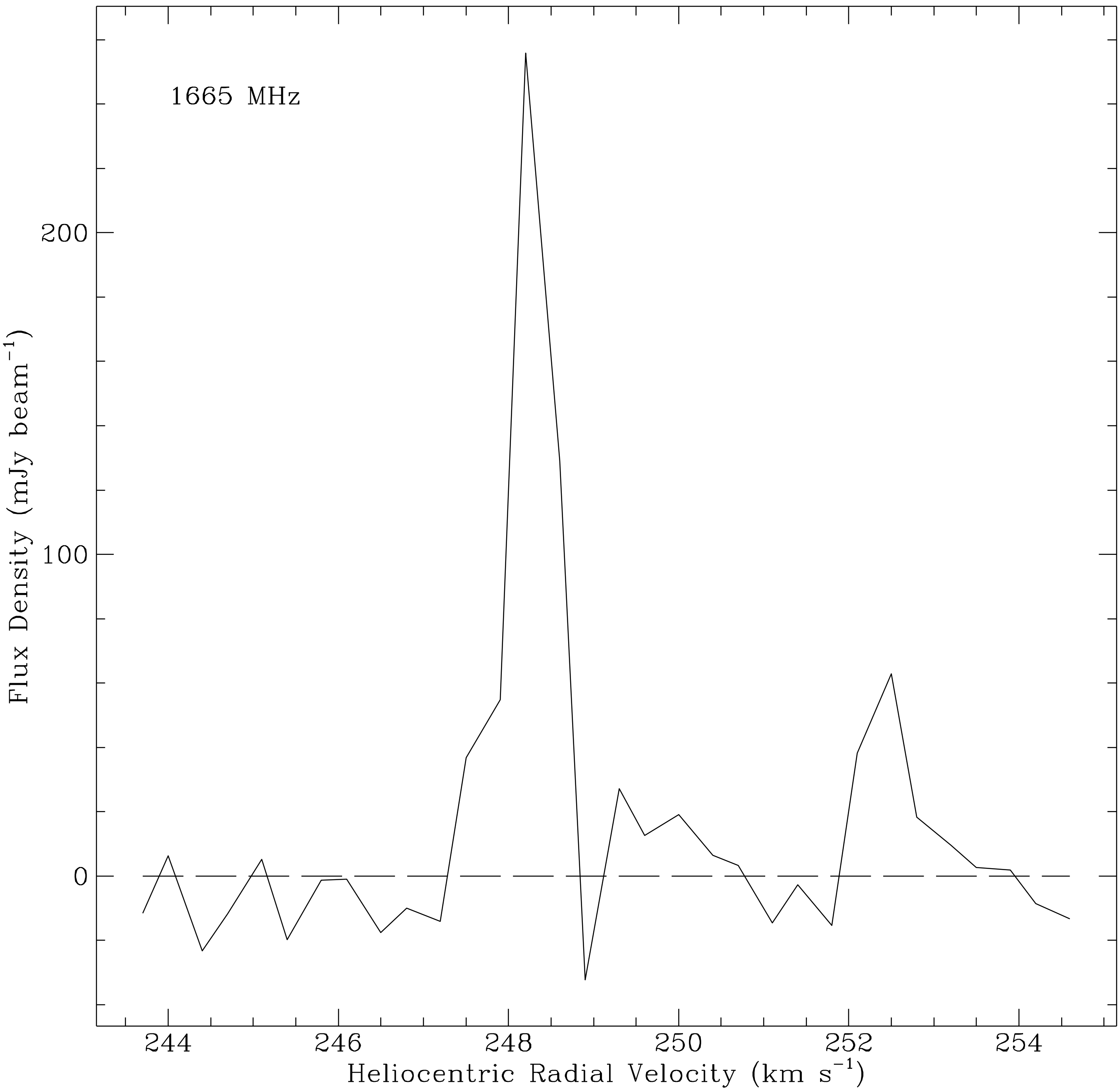
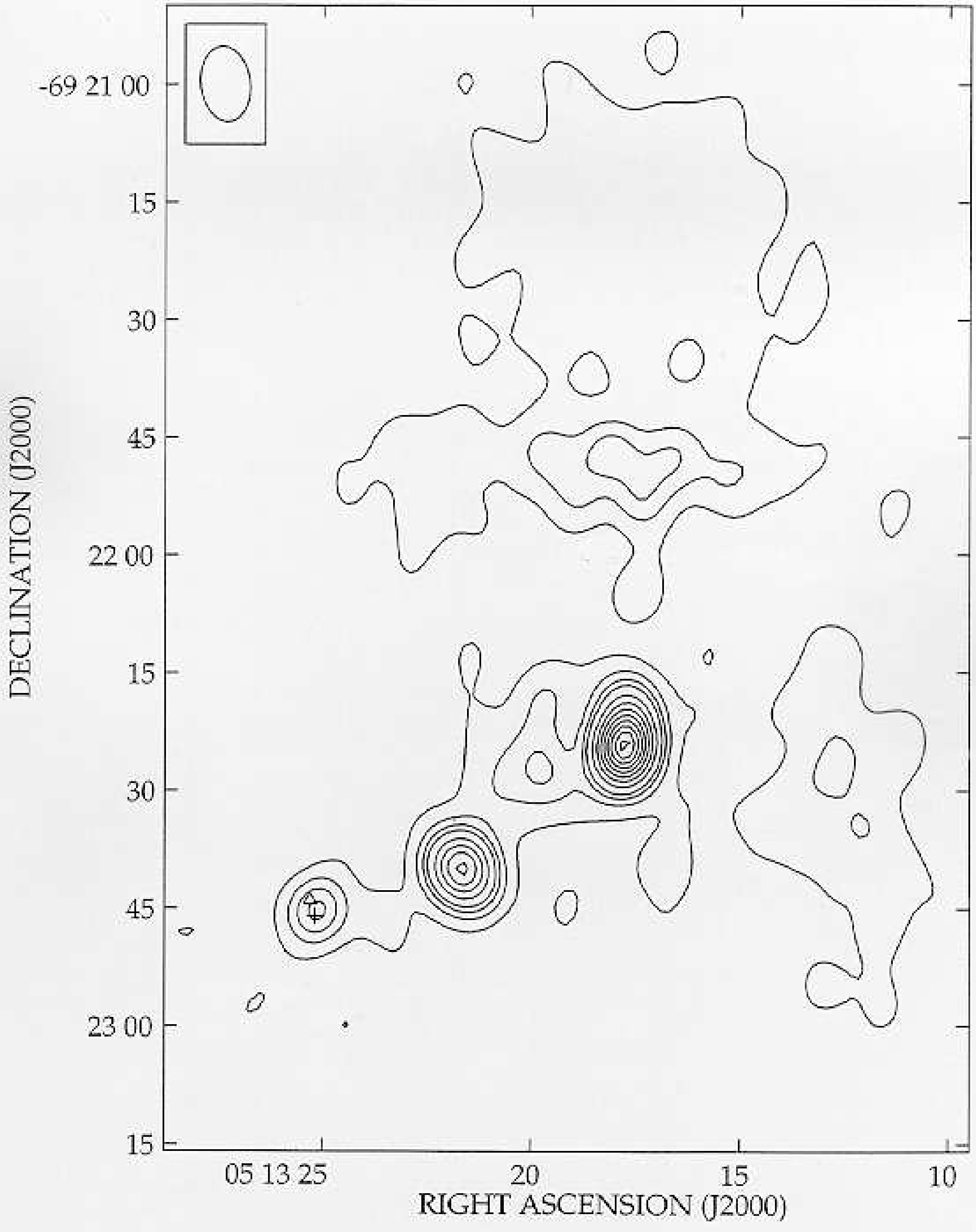
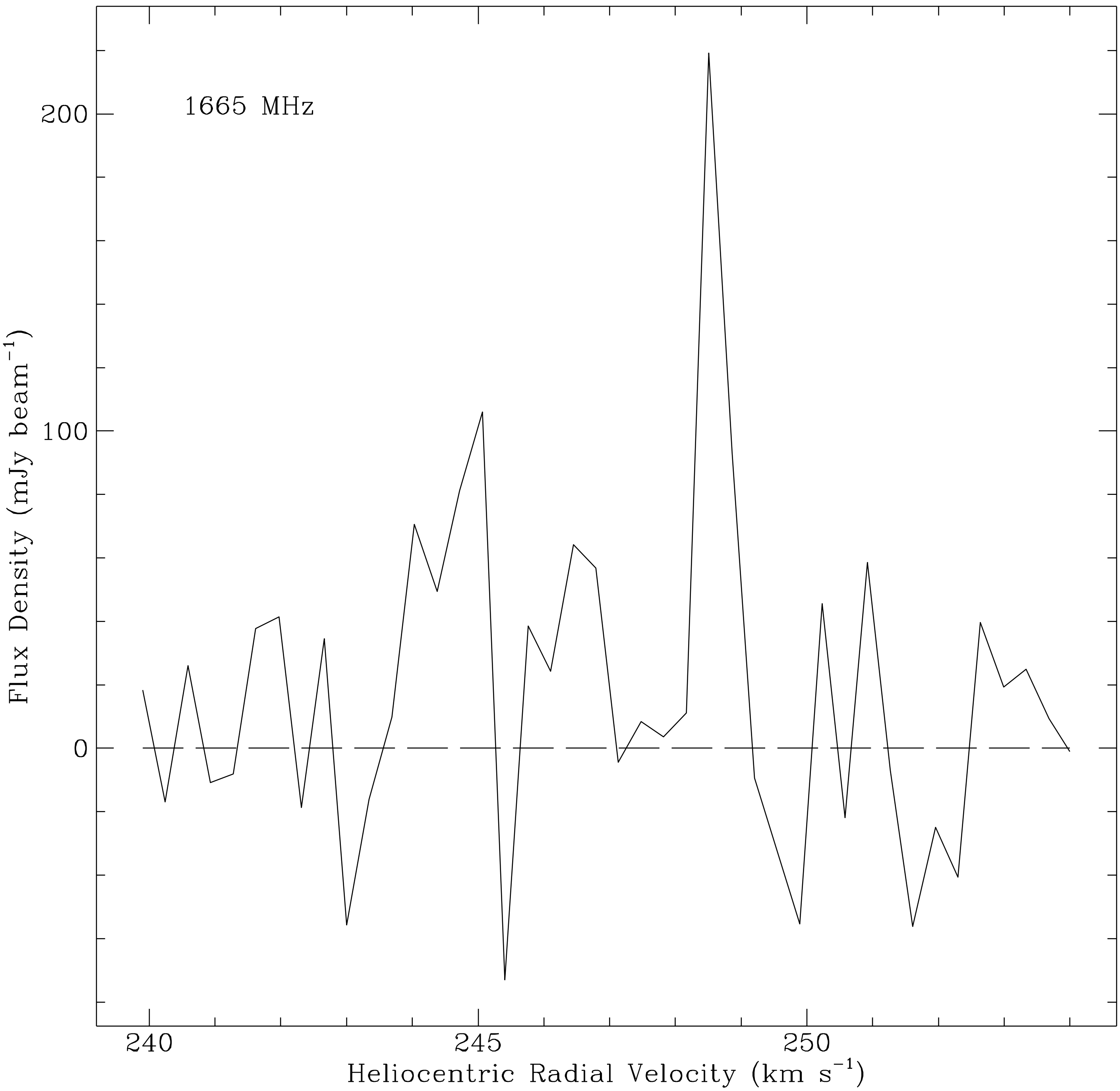
200
400
100
250
255
260


DECLINATION (J2000)
-68 52 45
53 00
15
30
45
05 10 02
00
09 58
56
54
52
50
48
46
RIGHT ASCENSION (J2000)

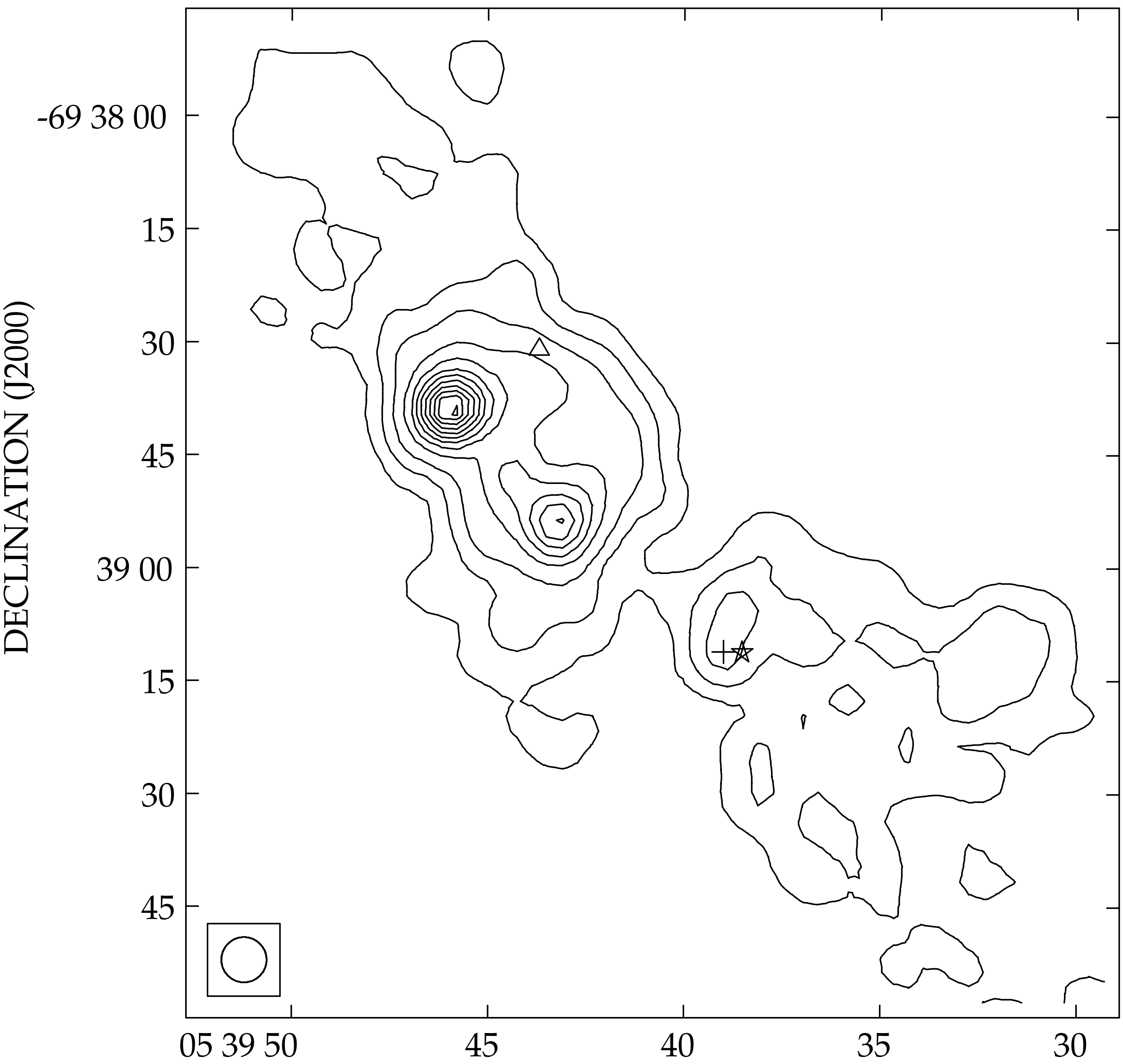

1665 MHz
Flux Density (mJy beam^{-1})
Heliocentric Radial Velocity (km s^{-1})
200
100
0
244
246
248
250
252
254



-69 21 00
15
30
45
22 00
15
30
45
23 00
15
DECLINATION (J2000)
05 13 25
20
15
10
RIGHT ASCENSION (J2000)



1665 MHz
200
100
0
240
245
250
Flux Density (mJy beam^{-1})
Heliocentric Radial Velocity (km s^{-1})



-69 38 00
15
30
45
39 00
15
30
45
DECLINATION (J2000)
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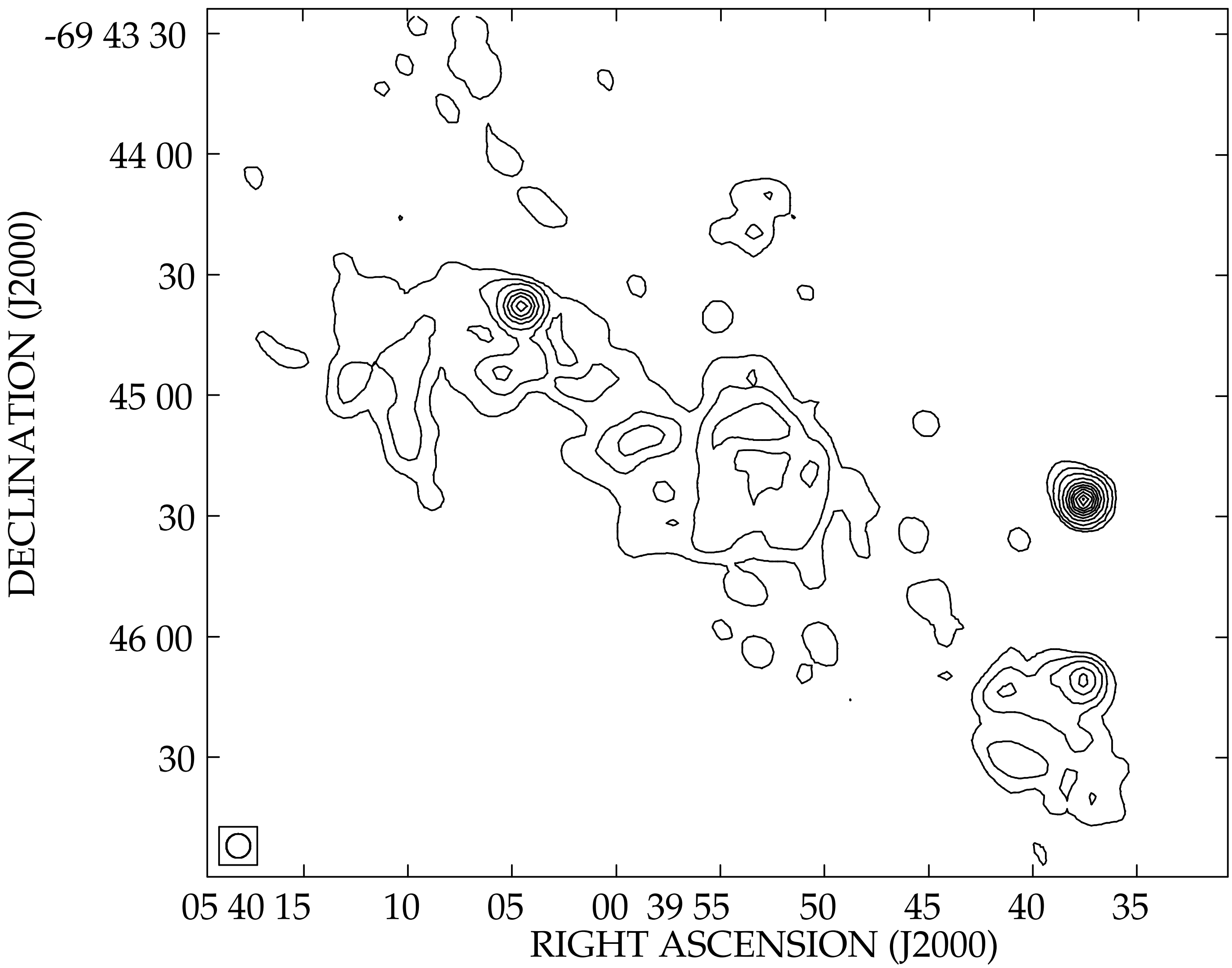
40
35
30
RIGHT ASCENSION (J2000)



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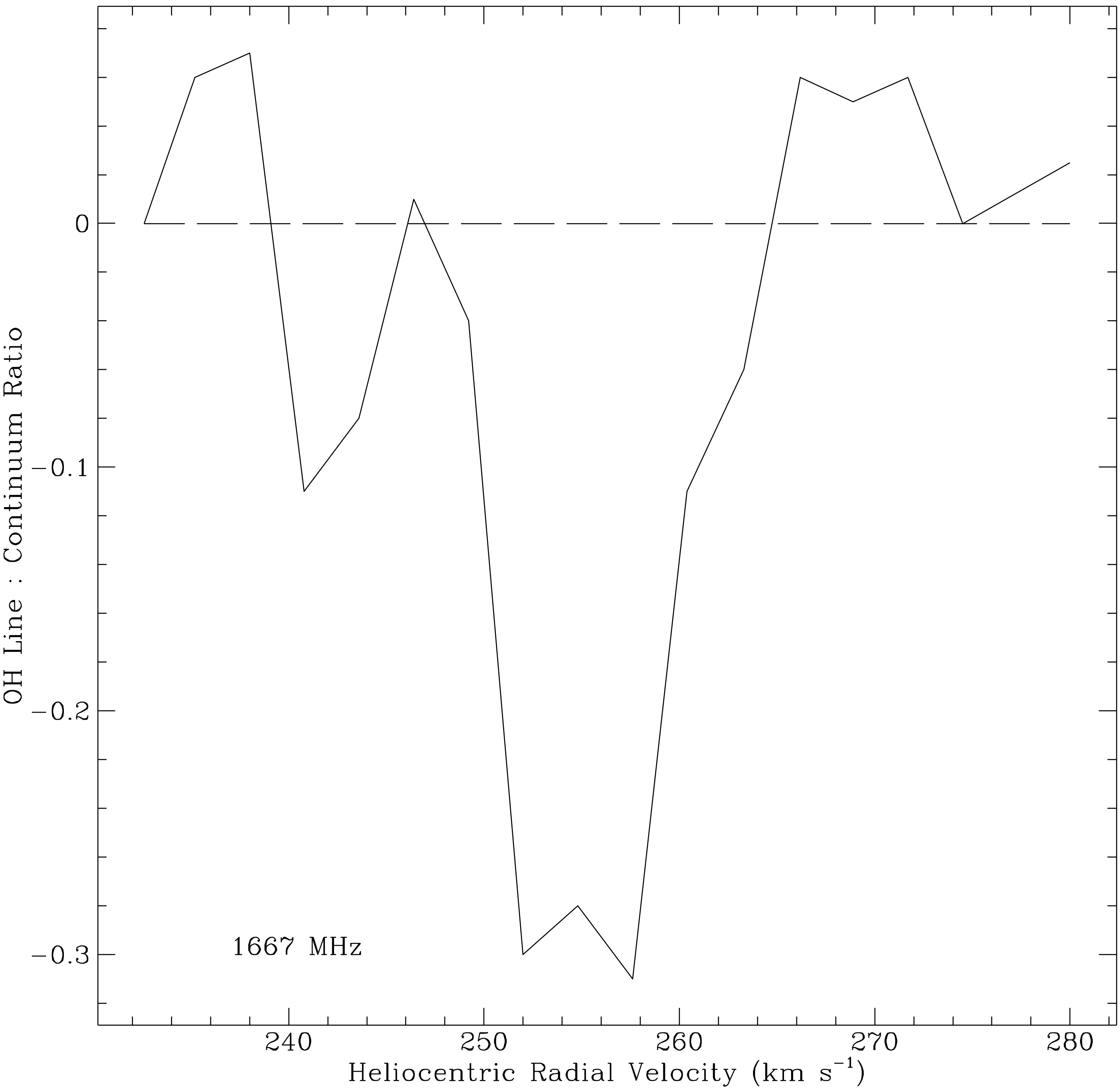
44 00
30
45 00
30
46 00
30
DECLINATION (J2000)
05 40 15
10
05
00
39 55
50
45
40
35
RIGHT ASCENSION (J2000)



0
−0.1
−0.2
−0.3
240
250
260
270
280
OH Line : Continuum Ratio
Heliocentric Radial Velocity (km s⁻¹)
1667 MHz